

WHAT IS CLAIMED IS:

1 1. A projection exposure apparatus for projecting a pattern image
2 formed on a mask onto a photosensitive substrate through a projection optical
3 system to form a projected image thereon, the projection exposure apparatus
4 comprising:

5 a substrate position detector that detects a position of a registration
6 mark formed on the substrate;

7 an imagery characteristic correction mechanism coupled with the
8 projection optical system that drives the projection optical system to correct an
9 imagery characteristic of the projection optical system;

10 an image-forming displacement detector communicating with said
11 imagery characteristic correction mechanism, said image-forming displacement
12 detector determining a displacement amount of an image-forming position of the
13 projected image in accordance with a driven amount of the projection optical
14 system by said imagery characteristic correction mechanism; and

15 an alignment signal processor communicating with said substrate
16 position detector and said image-forming displacement detector, said alignment
17 signal processor correcting the detection result of the substrate position detector
18 based on the displacement amount of the image-forming position obtained by the
19 image-forming displacement detector.

1 2. The projection exposure apparatus of claim 1, further comprising a
2 memory storing a relation between the driven amount of the projection optical
3 system by said imagery characteristic correction mechanism and the displacement
4 amount of the image-forming position, said image-forming displacement detector
5 communicating with said memory.

1 3. The projection exposure apparatus of claim 2, wherein said
2 projection optical system comprises the mask and at least one optical element that
3 projects the pattern image formed on the mask onto the photosensitive substrate,
4 said imagery characteristic correction mechanism having a driving device coupled
5 to the mask and said optical element, said driving device driving or tilting at least
6 one of the mask or said optical element along an optical axis direction of the
7 projection optical system or with respect to a plane perpendicular to the optical
8 axis.

1 4. The projection exposure apparatus of claim 2, further comprising a
2 pressure adjustment mechanism communicating with said imagery characteristic
3 correction mechanism, said projection optical system comprising at least two
4 optical elements disposed along the optical axis, said optical elements defining a
5 sealed space therebetween, wherein said imagery characteristic correction
6 mechanism controls said gas pressure adjustment mechanism to change a gas
7 pressure in said sealed space.

1 5. The projection exposure apparatus of claim 1, wherein said
2 projection optical system comprises the mask and at least one optical element that
3 projects the pattern image formed on the mask onto the photosensitive substrate,
4 said imagery characteristic correction mechanism having a driving device coupled
5 to the mask and said optical element, said driving device driving or tilting at least
6 one of the mask or said optical element along an optical axis direction of the
7 projection optical system or with respect to a plane perpendicular to the optical
8 axis.

1 6. The projection exposure apparatus of claim 1, further comprising a
2 pressure adjustment mechanism communicating with said imagery characteristic
3 correction mechanism, said projection optical system comprising at least two

4 optical elements disposed along the optical axis, said optical elements defining a
5 sealed space therebetween, wherein said imagery characteristic correction
6 mechanism controls said gas pressure adjustment mechanism to change a gas
7 pressure in said sealed space.

1 7. The projection exposure apparatus of claim 1, further comprising
2 at least one displacement detector secured to the projection optical system and
3 communicating with said image-forming displacement detector, said
4 displacement detector detecting the driven amount of the projection optical
5 system by said imagery characteristic correction mechanism.

1 8. The projection exposure apparatus of claim 1, further comprising
2 an environmental sensor disposed adjacent the projection optical system and
3 communicating with said imagery characteristic correction mechanism.

1 9. A projection exposure apparatus for projecting a pattern image of a
2 mask through a projection optical system onto a photosensitive substrate to form
3 a projected image thereon, the projection exposure apparatus comprising:
4 a substrate position detector that detects a position of a registration
5 mark formed on the substrate;
6 an imagery characteristic correction mechanism coupled with the
7 projection optical system that drives the projection optical system to correct an
8 imagery characteristic of the projection optical system;
9 a base-line amount measuring device that measures a distance
10 between a detection center of said substrate position detector and a center of the
11 projected image formed through the projection optical system, said distance
12 defining a base-line amount; and
13 an alignment signal processor communicating with said substrate
14 position detector and said base-line amount measuring device, said alignment

15 signal processor correcting the detection result of the substrate position detector
16 based on the base-line amount.

1 10. The projection exposure apparatus of claim 9, wherein said base-
2 line amount measuring device comprises a reference plate disposed adjacent and
3 substantially level with the photosensitive substrate, said reference plate including
4 primary alignment marks corresponding to alignment marks on the mask.

1 11. The projection exposure apparatus of claim 10, wherein said
2 reference plate includes a secondary alignment mark disposed adjacent said
3 substrate position detector during initial alignment, said substrate position
4 detector determining an offset amount in accordance with a distance between a
5 center point between said primary alignment marks and said secondary alignment
6 mark.

1 12. The projection exposure apparatus of claim 10, wherein said base-
2 line amount measuring device further comprises a pair of mask alignment
3 microscopes, said mask alignment microscopes being disposed adjacent the
4 alignment marks on the mask for detecting the alignment marks on the mask.

1 13. A method of projecting a pattern image formed on a mask onto a
2 photosensitive substrate through a projection optical system having an optical
3 axis to form a projected image thereon, the method comprising:
4

5 (a) detecting with a substrate position detector a position of a
6 registration mark formed on the substrate;

7 (b) driving the projection optical system to correct an imagery
8 characteristic of the projection optical system;

9 (c) determining a displacement amount of an image-forming
position of the projected image formed through the projection optical system in

10 accordance with a driven amount of the projection optical system in step (a); and
11 (d) correcting the detected position from step (a) based on the
12 displacement amount.

1 14. The method of claim 13, wherein a memory stores a relation
2 between the driven amount of the projection optical system and the displacement
3 amount of the image-forming position, said step (c) being practiced by accessing
4 the displacement amount stored in the memory in accordance with the driven
5 amount.

1 15. The method of claim 14, wherein step (b) is practiced by driving or
2 tilting at least one of the mask or an optical element of the projection optical
3 system along an optical axis direction of the projection optical system or with
4 respect to a plane perpendicular to the optical axis.

1 16. The method of claim 14, wherein step (b) is practiced by
2 controlling a gas pressure in a space defined by optical elements of the projection
3 optical system.

1 17. The method of claim 13, wherein step (b) is practiced by driving or
2 tilting at least one of the mask or an optical element of the projection optical
3 system along an optical axis direction of the projection optical system or with
4 respect to a plane perpendicular to the optical axis.

1 18. The method of claim 13, wherein step (b) is practiced by
2 controlling a gas pressure in a space defined by optical elements of the projection
3 optical system.

1 19. The method of claim 13, wherein step (c) is practiced by, prior to
2 step (b), measuring a distance between a detection center of the substrate position
3 detector and a center of the projected image formed through the projection optical
4 system defining a base-line amount, and after step (b), again measuring the base-
5 line amount.

1 20. The method of claim 19, wherein a base-line amount measuring
2 device for measuring the base-line amount includes a reference plate disposed
3 adjacent and substantially level with the photosensitive substrate, the reference
4 plate including primary alignment marks corresponding to alignment marks on
5 the mask and a secondary alignment mark disposed adjacent the substrate position
6 detector during initial alignment, wherein step (c) is further practiced by
7 determining an offset amount in accordance with a distance between a center
8 point between the primary alignment marks and the secondary alignment mark,
9 and adding the offset amount to the base-line amount.

1 21. The method of claim 13, further comprising, prior to step (a) the
2 step of (e) aligning the mask with respect to the projection optical system.

1 22. The method of claim 21, wherein step (e) is practiced by:
2 (e1) detecting positions of projected images of at least two
3 alignment marks formed on the mask, the alignment marks having a
4 predetermined positional relationship with the pattern image;
5 (e2) changing a magnification of the projection optical system;
6 (e3) detecting the positions of the projected images after step (e2);
7 and
8 (e4) adjusting the mask position based on the positions of the
9 projected images determined in steps (e1) and (e3).

1 23. The method of claim 22, further comprising the step of repeating
2 steps (e1) through (e4) until a center of the pattern image projected onto the
3 photosensitive substrate is aligned with the optical axis even after the
4 magnification of the projection optical system has been changed.

1 24. The method of claim 22, comprising the steps of replacing the
2 mask with a second mask and positioning the second mask in the same position as
3 the first mask based on mask position information obtained in step (e4).

1 25. The method of claim 24, wherein the mask position information is
2 a position of a reference mark corresponding to the mask position adjusted in step
3 (e4).

1 26. The method of claim 24, wherein the mask position information is
2 information supplied from a mask position adjusting mechanism during the mask
3 adjustment performed in step (e4).

1 27. A mask alignment method for aligning a mask with respect to a
2 projection optical system having an optical axis prior to transferring a pattern
3 image of the mask onto a photosensitive substrate through the projection optical
4 system, the method comprising:

5 (a) detecting positions of projected images of at least two
6 alignment marks formed on the mask, the alignment marks having a
7 predetermined positional relationship with the pattern image;

8 (b) changing a magnification of the projection optical system;

9 (c) detecting the positions of the projected images after step (e2);

10 and

11 (d) adjusting the mask position based on the positions of the
12 projected images determined in steps (a) and (c).

1 28. The method of claim 27, further comprising the step of repeating
2 steps (a) through (d) until a center of the pattern image projected onto the
3 photosensitive substrate is aligned with the optical axis even after the
4 magnification of the projection optical system has been changed.

1 29. The method of claim 27, comprising the steps of replacing the
2 mask with a second mask and positioning the second mask in the same position as
3 the first mask based on mask position information obtained in step (d).

1 30. The method of claim 29, wherein the mask position information is
2 a position of a reference mark corresponding to the mask position adjusted in step
3 (d).

1 31. The method of claim 29, wherein the mask position information is
2 information supplied from a mask position adjusting mechanism during the mask
3 adjustment performed in step (d).

DIGITAL DOCUMENT SYSTEM